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The Role of Environmental Sustainability, Foreign Direct Investment and Trade Openness in Economic Growth: with Emphasis on the Causal Linkage

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Abstract

Foreign Direct Investment (FDI) and environmental quality contributes very significantly to all parts of the world, especially developing countries. These two factors have been so important that are known as the engine of economic growth and progression. This paper aimed to examine the association between environmental sustainability index, economic growth, and FDI in selected developing countries. Estimation of long-run coefficients is carried out by using Dynamic Ordinary Least Square (DOLS) and Fully Modified Ordinary Least Square (FMOLS), and the estimation of short-term coefficients and causality relationships using Pooled Mean Group (PMG) method in panel data for intervals 2000-2020. The outcomes of long-term estimates of variables indicate that each variable is statistically significant; so that, FDI has the greatest effect on the economic growth. The environmental quality index had a significantly positive impact on the economic growth; so that, after FDI variable, it significantly affected economic growth in selected developing countries. There is a significantly positive relationship between FDI and quality of environment and economic growth in short term. In the equation of environmental quality index, economic growth, FDI and trade openness show a significantly negative impact on quality of environment in the short term. Generally, as it was observed from the short-term and long-term relationships, the association between economic growth and quality of environment is a two-way causality relationship.

Keywords: Environmental sustainability index, Trade openness, FDI, Economic growth.

1 | Introduction

There has been a great deal of interests and debates on the association between trade openness, environmental sustainability, FDI, and economic growth in theoretical and empirical publications over the past few decades. As we know, economic growth has always been considered as one of the most important indexes for development assessment in countries, so that it has attracted considerable focus of the economists and other scholars including the environmental economists [1] and [2]. This is because the achieving higher economic growth requires more and irregular consumption of natural

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resources and energy, especially fossil fuels. One adverse and direct environmental consequence of such consumption has been the global warming and climatic changes. Hence, simultaneous with achieving higher economic growth, the environmental risks arising out of the economic activities has become a controversial topic among the environmental economists. [3], [4], [5] and [6]. The resulting environmental dangers can also directly or indirectly affect the economic and social status of the countries. As an example, a major consequence of negative and direct impacts of environmental problems like global warming is the decline of production factors' productivity (economic status) and health disorderliness (social status) [7].

Having this said, there are numerous factors that influence economic growth. FDI is a factor related to economic growth. Since improving of development and welfare of the country is a key goal of the governments, FDI has been considered as an important factor for growth and development. Depending on the development level, FDI can have different impacts on economic growth [8], [7] and [9]. This means that in the developed countries, the increase in FDI is a main factor of technology transfer, promoting productivity and economic growth [10]. This is not necessarily the case for the developing countries and sometimes it will consequence opposite results for the simple fact that considering the low level of human capital in developing countries, there is no possibility for the technology transfer through FDI, virtually impending the higher productivity and exploiting the technology surplus, and conversely, it acts as an impending factor in the way of economic growth in these countries [10] and [11].

In addition, regarding the studies, the link between the degree of economic growth and trade openness has always been a disputable issue in the literature of progression and economic growth, which is still unresolved and remains one of the most challenging issues. Theoretical studies of growth in the best of terms imply a vague and complex association between commerce restrictions and economic growth. Papers published on endogenous growth are large enough to introduce different patterns of trade restrictions that lead to an increase or decrease in economic growth [12], [13] and [14]. Meanwhile, classical and neoclassical economists believe that increasing the degree of trade openness is the engine for driving economic growth. This will encourage all the countries to enhance convergence of their economies by increasing exports and imports. In general, this is done by increasing the level of expertise and productivity of countries. It should be noted that even with the assumption that economic convergence and increased trade lead to higher global economic growth, this relationship has not always been the same in different countries due to differences in technology and the frequency of factors of production, and in fact in some countries have had a negative impact on economic growth [15] and [16].

In order to investigation of environmental quality effects on economic growth, environmental sustainability index is utilized as an environmental indicator. The mentioned index evaluates the capacity and competence of the countries for supporting the environment in several future decades, extracted from 76 statistical groups merged in the framework of 21 environmental sustainability indexes. In effect, the environmental sustainability index is general score seeking to indicate a country's environmental ranking and status compared with another country for the sake of creating a constructive competition. Accordingly, the higher score of environmental sustainability a country has achieved, it will have better environmental conditions in the future. The ranking and scoring of the environmental sustainability index have been affected through the comparison of issues organized in 5 groups: environmental policies; reducing environmental pressures; reducing human vulnerability (stemming from environmental pressures); social and institutional capacity for assuming responsibility for environmental challenges; global supervision.

According to above mentioned explanations, the scope of this paper is to investigate relationship between environmental sustainability, FDI and trade openness with economic growth emphasizing on the causal linkage in selected developing and developed countries.

General structure of the paper includes six parts. This is the introductory part of the paper. The "Literature review" contains three sub-parts in which each sub-parts are dedicated to the relationships of the studied variable with economic growth; The "Data and description of variables" section deals with data obtained; The "Econometric methodology" part explains econometric methodology; "Empirical results" section represents the empirical analysis of results and finally, the summary of the findings and policy implications are described in the "Conclusion" section.

2 | A Brief Review of the Literature

This part is broken into 3 sub-sections. The first sub-part is dedicated to FDI on economic growth. The second sub-part reviews the major works exploring the role of trade openness in economic growth. Finally, the last sub-parts review the researches exploring the association between environmental quality and economic growth. *Table A1* (Appendix A) reviews a summary of the previous studies that have explored the relationship between environmental sustainability, trade openness, FDI and economic growth.

2.1 | Economic Growth And FDI

Association between economic growth and FDI has always been considered based on the theoretical and empirical perspectives in both developed and developing countries. A lot of publications investigated the role of FDI and economic growth. According to neoclassical theories, FDI could be considered as the wheel of economic growth because of some reasons: (a) FDI can augment the capital formation and employment amplification; (b) FDI can improve manufacturing exports; (c) FDI can bring technology transfer and spillover effects [17].

Several investigations indicate that developing countries respond to FDI differently in economic growth. In other words, according to these empirical literatures, there are paradoxical findings. Firstly, numerous researches have been done that verify the positive impact of FDI on economic growth via externality and spillover impact [18]. These empirical investigations indicates that FDI functions as technology transfer mechanism by increasing the productiveness and functions just as the country which receives technology transfer satisfies a minimum threshold of human capital stock [19], [20] and [21]. The reason for this condition is that while the number of human capitals in the country that receives a FDI is low and the technology transfer costs highly. Secondly, there have been several studies in which the negative effects of FDI on economic growth is validated [22] and [23]. This conclusion maybe comes from the time of research and kind of their efficient structures. Thirdly, the other investigations have indicated that FDI wouldn't impact economic growth [24] and [25]. For example, Carkovic and Levine [19] and Curwin and Mahutga [20] shows that there is not a sturdy and independent impact on economic growth and FDI does not always speed up the economic growth.

2.2 | Trade Openness and Economic Growth

We observed a large volume of published studies describing the role of trade openness in economic growth. This variable has been one of the significant macro-economic factors which were widely investigated in the area of economic growth (See [21] and [22]). There exist various and contradictory perspectives in respect of the linkage of economic growth with trade openness, categorizable into two groups:

The first perspective refers to trade openness as the driving motor of the economic growth and advocates believe that it can accelerate the economic growth. Neo-classical economists are among the supporters of this perspective, believing that to achieve the economic growth, the trade openness must be promoted. In their view, broadening of the markets will result in global production growth as well as the domestic and foreign economies and ultimately will consequence higher income for whole economy. On the other hand, with appearance of internal growth notions, a precise and convincing theoretical base was provided for this point of view, showing the positive association between the economic growth and the trade openness. On the whole, based on this perspective, the reduction or elimination of commercial restrictions can

increase the economic growth in various ways: a) Growth of the benefits emanating from the scale in production; b) Decrease of the price difference and achieving more efficient use of the economy sectors' resources; c) Encouraging greater allocation and higher efficiency in production of intermediary inputs; d) Making attempts to quicker production of goods and services.

Based on the second perspective, the trade constitutes a major factor in reduction of growth and economic development of developing countries. They questioned the trade relationship between the developed and under-developed countries and remind that economic growth and structural reform of developing countries are dependent upon the developed countries and in fact imposed by them which in long-term causes deterioration of potential positive effects of trading on their growth (See [23], [24], [25] and [26]).

2.3 | Environmental Sustainability and Economic Growth

The environment is one of the main pillars of sustainable development [27]. In this regard, the development process is being designed, so that while maximizing the value added of economic activities, the system of nature does not lose its equilibrium dynamics. Since less developed or developing countries are pursuing their development process by targeting a higher level of economic growth, economic growth has become one of the most important concerns of countries in recent decades. It seems that developed countries are simultaneously at a high level of economic growth, and it is heavily involved in the formation and strengthening of this mentality.

Several studies investigating environmental quality have been carried out on economic growth. However, it can be noted that much published researches on this issue didn't have unique and uniform outcomes. A specific dimension; that is, association between environment with economic growth or development has been accompanied by a lot of discussions in the past decade and considerable publications on the association between pollution and earning growths in current era [28] and [29]. Similarity in the researches is that they all assert quality of environment declines in the earliest phase of economic growth or development and enhances in the last phase when the economy progresses. On the other hand, environmental pressure augments more rapidly in comparison to the earning in the earliest phase of progression and decreases compared with the growth of GDP in greater earning amounts. This systematized association between changes in incomes and quality of environment was labled as Environmental Kuznets Curve (EKC). This hypothesis assumes a clear-cut association of the number of economic activities and environmental pressure (described as the amount of pollution concentrations or emission flows, resources depletion, and so on). In brief, EKCs are statistical artifacts summarizing some chief dimensions of general behaviors of humans in two-dimensional space [30], [31] and [32].

3 | Data and Description of Variables

In this study, panel data on economic growth, FDI, trade openness and labors have been used in selected developing countries for 2000 to 2020 interval. Data were collected via various sources, such as International Monetary Fund, quarterly bulletin, and so forth. Moreover, a variety of volumes of International Financial Statistics (IFS) Yearbook released by World Development Indicators (WDI) and International Monetary Fund reported online by the World Bank were employed for supplementing local information. Information related to labor and FDI originated from quarterly bulletins and volumes of the IFS Yearbook. ESI had been released by Yale University's Center for Environmental Law and Policy in coordination with Columbia University's Center for International Earth Science Information Network (CIESIN), and the World Economic Forum.

4 | Econometric methodology

The intended model in this paper is a panel equation. In the econometrics of the panel, in general, it is assumed that the used data have a cross-sectional independence. However, interdependence between

the sections can be due to factors such as external implications, regional and economic relations, the interrelation of the remaining terms that is not calculated, and unusual factors that are not observed in different intervals. Therefore, the first step in the econometric analysis of the panel data is the determination of the cross-sectional independence of the data. For this purpose, several tests have been provided such as Breusch and Pagan [33] and Pesaran *CD* [34] and in this study, the test of Pesaran *CD* has been used. This test is applicable to the balance and disassembled panel data and it has desirable properties for small specimens. Also, in spite of the Breusch and Pagan method [33], it has presented reliable results for large cross-sectional dimensions and short-run dimensions, and it is resistant to individual regression slope coefficients in one or more structural failures [34]. The null hypotheses and the rival of this test are defined as follows:

$$H_0: p_{ij} = p_{ij} = E(u_{it}, v_{it}) = 0 \text{ for all } i \neq j,$$
$$H_1: p_{ij} = p_{ij} = E(u_{it}, v_{it}) \neq 0 \text{ for all } i \neq j. \quad (1)$$

For benchmark panels, the fixed effect test of *CD* can be calculated as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N}\sum_{j=i+1}^{N}\hat{P}_{ij}\right) \rightarrow N(0,1). \quad (2)$$

In the above equation, $\hat{P}_{ij}$ is the correlation coefficients of pair of Pearson pairs from residuals of the regression equation $y_{it} = \alpha_i + \beta_i x_{it} + u_{it}$. If the fixed effect test of the computational *CD* is more than the critical value of the standard normal distribution at a certain significant level, then the null hypothesis of crosssectional interdependence rejection will be deduced.

Whenever a crosssectional affinity has been approved in panel data, the use of conventional panel unit root methods will increase probability of occurrence of false unit root results. In order to solve this problem, different panel unit root tests have been suggested in spite of the existing Crosssectional Dependence (CSD). One of the most popular of these tests is the test of cross-sectional generalized unit root of Im et al (CIPS) that has been presented by Pesaran [35]. In order to formulate this test, considering dependence between the sections, Pesaran have used the cross-sectional Augmented Dicky Fuller regression (ADF) which is estimated with using the Ordinary Least Square method for the i-th section.

Moreover, in the case of the confirmation of crosssectional dependence, the use of conventional panel co-integration methods such as Pedroni [36] and Kao and Chiang [37] will increase the probability of occurrence of false co-integration results. To overcome this problem, several panel co-integration tests have been proposed, including the one suggested by Westerlund [39]. Basis of the design of this test is the fact that the null hypothesis is based on the lack of co-integration, whether correcting the error in the model of conditional error correction is 0 or not, is examined and tested. Therefore, rejection of the null hypothesis based on the error correction can demonstrate rejecting null hypothesis related to lack of cointegration. Westerlund [39] has suggested 4 distinct statistics to examine panel co-integration. The panel statistics p_τ and p_α survey the test of the assumption of lack of co-integration against the hypothesis of co-existence, and the statistics of mean group of G_τ and G_α survey the test of the assumption of lack of co-integration against the presence of at least a vector of cointegration.

Westerlund [39] has used the Bootstrap method for removing the effects of crosssectional dependence on the variables. With using co-integration tests such as Pedroni [36] and Westerlund [39], we can only study the being or lack of long-term linkage between the model elements. These methods are not able to estimate the long term and short-term coefficients of these variables.

4.1 | DOLS and FMOLS

In panel models, if there is a co-integration relationship, various estimators will be used to estimate convergence vectors such as Ordinary Least Squares (OLS), and (PMG) methods, FMOLS, and DOLS. Pedroni [38] suggested the FMOLS method, but Kao and Chiang, [37] and Mark and Sul [40] suggested the DOLS method for estimating the panel co-integration models. The FMOLS method is a nonparametric method that calculates the probable correlation between the model error components and the first-order difference of the explanatory variables with constant coefficient for the correction of serial correlation and corrects non-parametric OLS estimator [41]. The estimator of DOLS uses the parametric modifications for the error terms with a difference using the aggregation of a stationary regression with interruptions and the current values of the regression and the past and future values of explanatory variables consider a difference as additional variables in estimation. These two methods of the efficient and consistent estimators are used for investigating long-term relationships and examine both serial correlation and potential endogeneity methods between the variables [42].

The estimator of FMOLS has been proposed by Pedroni in order to resolve the endogeneity between the regressors. Consider the following model to evaluate the estimator of FMOLS:

$$Y_{i,t} = \alpha_i + \beta_i X_{i,t} + \varepsilon_{it} \qquad \forall t = 1, \dots, T \quad i = 1, \dots, N. \tag{3}$$

In this equation, it is assumed that $Y_{i,t}$ and $X_{i,t}$ are accumulated with the slope β_i and β_i may also be either homogeneous or heterogeneous between the different sections of i. This equation can be rewritten as follows:

$$Y_{i,t} = \alpha_i + \beta_i X_{i,t} + \sum_{j=k_i}^{k_i} \gamma_{i,t} \Delta X_{i,t-k} + v_{it} \qquad \forall t = 1, \dots, N. \tag{4}$$

In this model, the variable X represents the vector of the explanatory variables of the model ($X = [ESI, FDI, TO, L]$) and the coefficient of $\gamma_{i,t}$ with the first-order difference lag of the explanatory variables of the model. With assuming $\xi_{i,t} = \left(\hat{\varepsilon}_{i,t}, \Delta X_{i,t}\right)$, the result will be $\Omega_{i,t} = Lim\ E\left[\frac{1}{T}\left(\sum_{t=1}^{T} \xi_{i,t}\right)\left(\sum_{t=1}^{T} \xi_{i,t}\right)\right]$ and it is equal to the long-term quarantine of the process, which can be analyzed in this way $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i'$. In this equation, there is Ω_i^0 is simultaneous covariance and Γ_i is total weight of autocoarance. In this model, the estimated coefficient of FMOLS estimator is equal to:

$$\hat{\beta}^*_{FMOLS} = \frac{1}{N} \sum_{i=1}^{N} \left[\left(\sum_{t=1}^{T} \left(X_{i,t} - \bar{X}_i \right)^2 \right)^{-1} \left(\sum_{t=1}^{T} \left(X_{i,t} - \bar{X}_i \right)^2 Y_{i,t} - T\hat{\gamma}_i \right) \right]. \tag{5}$$

In this equation, $Y^*_{i,t} = Y_{i,t} - \bar{Y}_i - \frac{\hat{\Omega}_{2,1,i}}{\hat{\Omega}_{2,2,i}} \Delta X_{i,t}$, and $\hat{\gamma}_i = \hat{\Gamma}_{2,1,i} + \hat{\Omega}^0_{2,1,i} - \frac{\hat{\Omega}_{2,1,i}}{\hat{\Omega}_{2,2,i}} \left(\hat{\Gamma}_{2,2,i} + \hat{\Omega}^0_{2,2,i} \right)$.

The DOLS estimator uses a long-term parameter for achieving to an unbiased estimator and the parametric modification of the model errors through entering past and future values of the first-order difference in the explanatory variables in order to obtain the endogeneity correction of the variables used in this model. The estimated coefficient of DOLS estimator in this model equals to:

$$\hat{\beta}^*_{DOLS} = \frac{1}{N} \sum_{t=1}^{N} \left[\left(\sum_{t=1}^{T} z_{i,t} z'_{i,t} \right)^{-1} \left(\sum_{t=1}^{T} z_{i,t} y'_{i,t} \right) \right]. \tag{6}$$

In the above equation, $z_{i,t} = \left[X_{i,t} - \bar{X}_t, \Delta X_{t,t-k_i}, \dots, \Delta X_{t,t+k_i} \right]$, is the vector of regressors and $\tilde{y}_{it} = Y_{i,t} - \bar{Y}_i$ [34].

In co-integration panel models, the use of the OLS method to estimate the long-run relationship will lead to the biased results. Therefore, the use of this method will have no credible results.

FMOLS and DOLS estimators had little sample biased, and both of the estimators showed quite similar results that were appropriate for analysis [37]. In this study, the FMOLS and DOLS estimators are used to estimate a long-term relationship.

4.2 | Pooled Mean Group Estimator (PMG) and Causality Test

As it was expressed, the last step in the analysis of relationship between model variables in this study was for estimating the short-run and long-term coefficients of panel error correction model using the PMG method that is presented by Pesaran et al. [35], and then investigates the causality relation between the variables of the model.

Pooled mean group estimator is the intermediate estimator as it includes to pool and average. One of the advantages of the PMG method in comparison to the DOLS and FMOLS methods is that in this method, short-term dynamic properties can vary from one cross-section to another whereas the estimated long-run coefficients in the OLS, DOLS and FMOLS models are assumed to be uniform in all sections. In other words, in the PMG method, the various characteristics of the parts are considered in the estimation of coefficients. If the variables of the model are co-integrated, the PMG estimator can be applied to determine causality relationship between variables. Panel error correction model in this study is expressed below:

$$\Delta Y_{it} = \beta_{1j} + \sum_{k=1}^{p} \beta_{11ik}\Delta Y_{it-k} + \sum_{k=1}^{p} \beta_{12ik}\Delta ESI_{it-k} + \sum_{k=1}^{p} \beta_{13ik}\Delta FDI_{it-k} + \sum_{k=1}^{p} \beta_{14ik}\Delta TO_{it-k} + \sum_{k=1}^{p} \beta_{15ik}\Delta L_{it-k} + \lambda_{1i}\varepsilon_{it-1} + \nu_{1it}. \quad (7a)$$

$$\Delta ESI_{it} = \beta_{2j} + \sum_{k=1}^{p} \beta_{21ik}\Delta Y_{it-k} + \sum_{k=1}^{p} \beta_{22ik}\Delta ESI_{it-k} + \sum_{k=1}^{p} \beta_{23ik}\Delta FDI_{it-k} + \sum_{k=1}^{p} \beta_{24ik}\Delta TO_{it-k} + \sum_{k=1}^{p} \beta_{25ik}\Delta L_{it-k} + \lambda_{2i}\varepsilon_{it-1} + \nu_{2it}. \quad (7b)$$

$$\Delta FDI_{it} = \beta_{3j} + \sum_{k=1}^{p} \beta_{31ik}\Delta Y_{it-k} + \sum_{k=1}^{p} \beta_{32ik}\Delta ESI_{it-k} + \sum_{k=1}^{p} \beta_{33ik}\Delta FDI_{it-k} + \sum_{k=1}^{p} \beta_{34ik}\Delta TO_{it-k} + \sum_{k=1}^{p} \beta_{35ik}\Delta L_{it-k} + \lambda_{3i}\varepsilon_{it-1} + \nu_{3it}. \quad (7c)$$

$$\Delta TO_{it} = \beta_{4j} + \sum_{k=1}^{p} \beta_{41ik}\Delta Y_{it-k} + \sum_{k=1}^{p} \beta_{42ik}\Delta ESI_{it-k} + \sum_{k=1}^{p} \beta_{43ik}\Delta FDI_{it-k} + \sum_{k=1}^{p} \beta_{44ik}\Delta TO_{it-k} + \sum_{k=1}^{p} \beta_{45ik}\Delta L_{it-k} + \lambda_{4i}\varepsilon_{it-1} + \nu_{4it}. \quad (7d)$$

$$\Delta L_{it} = \beta_{5j} + \sum_{k=1}^{p} \beta_{51ik}\Delta Y_{it-k} + \sum_{k=1}^{p} \beta_{52ik}\Delta ESI_{it-k} + \sum_{k=1}^{p} \beta_{53ik}\Delta FDI_{it-k} + \sum_{k=1}^{p} \beta_{54ik}\Delta TO_{it-k} + \sum_{k=1}^{p} \beta_{55ik}\Delta L_{it-k} + \lambda_{5i}\varepsilon_{it-1} + \nu_{5it}. \quad (7e)$$

In above equations, Δ is the first-order difference operator and p denotes rate of system optimal lag, which is selected based on Schwarz-Bayesian criterion. With using the collection of above equations, it is possible to do analysis on both short term and long-term relationships between variables. In the equation of economic growth (relation *Eq. (7a)*), for investigating a short-run causality relationship among environmental quality index, FDI, economic openness and labor force with economic growth in each sector, it is possible to use these test $H_0: \beta_{12ik} = 0 \ \forall ik$ s, $H_0: \beta_{13ik} = 0 \ \forall ik$, $H_0: \beta_{14ik} = 0 \ \forall ik$ and $H_0: \beta_{15ik} = 0 \ \forall ik$ respectively. The coefficient β_{12ik} indicates the short-run causality relationship of the environmental

quality index to economic growth for different parts and lags and if this coefficient is zero, it indicates that the index of environmental quality and economic growth have nothing to do with each other. The coefficients β_{13ik}, β_{14ik} and β_{15ik} also indicate a short-run causality relation among FDI, the trade openness and labor force respectively for different parts and lags. In the equation of environmental quality, it is possible to examine a short-term causality association between economic growth, FDI, and trade openness of economy and labor force to the quality of the environment. In the system of high equations, the significance of the coefficients β, namely, the existence of short-term causality between variables is determined using statistical maturation of partial *F*, which is related to the right variables of the equations. The existence or non-existence of a long-term association between variables in above relations is also defined using the statistical significance level of t of the coefficient λ, which is related to the coefficient of model error ε_{it-1}.

5 | Results and Discussion

As it was already mentioned, the first step in estimating panel data is to conduct a cross-sectional dependence test. In this research, the cross-sectional dependence (CSD) test of Pesaran [34] for the analyzed model has been done and the statistic rate of test for each variable of model is presented in *Table 1*. With regarding the critical values of this test which has a normal distribution (and at 1%, 5% and 10%, it is -1.64, -1.96 and -2.57%, respectively), the null hypothesis related to lack of CSD is rejected at 1% level and the existing CSD between the model variables is concluded.

Table 1. Results of Pesaran's CD test for cross-sectional dependences in the ADF (p) regressions.

Variable	GDP	ESI	FDI	TO	L
P-value for CD statistic	-2.98(1)	0.3836(1)	0.2714(1)	0.4546(1)	0.3836(3)

*Note: Variable's lag length is shown in parentheses. According to null hypothesis of cross-sectional independence, CD statistic follows a 2-tailed standard normal distribution.

Therefore, according to the establishment of CSD in model, CIPS statistics of Pesaran [35] has been used to examine the existence or lack of the unit root. The results of this test for all of variables are expressed once with intercept (C), once with intercept and trend (C + T) at the level and with a difference in the upper part of *Table 2*. According to these results and the critical values presented by Pesaran [35] at the bottom of *Table 2*, we conclude that all of the variables will be nonstationary at level I(0), after a differentiation, they have been stationary at the first difference level I(1).

Table 8. Unit root test Pesaran [43].

	CIPS statistic				
	Level		First order differences		Stationary Degree
	C	C+T	C	C+T	
LGDP	-1.114	-2.162	-3.178	-3.342	I(1)
LESI	-1.732	-2.534	-3.789	-4.112	I(1)
LFDI	-1.381	-2.135	-4.113	-3.512	I(1)
LTO	-1.013	-1.854	-3.335	-3.114	I(1)
LLa	-0.126	-1.139	-2.431	-2.834	I(1)
Critical Values for Pesaran Unit Root Test in various Confidence of Level					
Status	1%		5%	10%	
C	-2.59		-2.38	-2.21	
C+T	-3.14		-2.87	-2.78	

Considering the existence of CSD in the analyzed model and results obtained by unit root test, and that each variable used in this study are co-integrated first order, the existence of long-term relationship of the intended model with the use of Westerlund Co-integration Test is analyzed [39]. These test findings are presented in *Table 3*. As it can be seen in *Table 3*, based on all of the panel statistics, the null hypothesis based on lack of a co-integration relationship at a confidence level of beyond 99% is rejected. In this test, robust p-value is calculated based on the bootstrapped p-value. These values have a very high

reliability for testing the hypothesis, and they also consider interdependence between the sections. Moreover, based on these values, the null hypothesis based on the lack of co-integration is rejected.

Table 3. Westerlund panel cointegration test.

	H_0: No existence of cointegration					
	With intercept			With intercept and trend		
	t-statistic	P-value	Robust p-value	t-statistic	P-value	Robust p-value
G_t	-4.895	0.045	0.001	-5.894	0.035	0.000
G_a	-5.975	0.065	0.000	-4.088	0.054	0.005
P_t	-5.876	0.021	0.001	-5.876	0.023	0.001
P_a	-4.643	0.001	0.000	-5.322	0.011	0.002

*The optimal lag length based on Schwarz information criterion is 1. The number of bootstraps for calculating the bootstrapped probabilities, which eliminates the effects of cross-sectional dependencies of panels, is also considered to be 400.

After performing the unit root and cointegration tests, diagnostic tests would be needed to determine the type of estimated model. In order to ensure the significance of a group of sample countries, an individual fixed effect test is used. For this purpose, *F* statistic is used. If the calculated statistic of *F* is larger than *F* of *Table 4*, then the hypothesis H_0 based on the equality of the intercept will be eliminated and intercept from different sources should be considered in estimation. As a result, we can use the panel method to estimate. The Hausman test is used to answer whether the variation in the length of the origin of the cross-sectional units is constant or those random operations can more clearly express this difference between the units. In the Hausman test, the H_0 hypothesis based on the compatibility of random effects estimations against the H_1 hypothesis based on the inconsistency of random effects estimates is tested. If the hypothesis H_0 is rejected, we must use the constant effects method to estimate. Otherwise, the estimation is done in the form of random effects.

Table 4. Results of fixed effect test.

Effecting test	t – statistic	Freedom degree	prob
Cross-F Section	31.7153	(8,116)	0.0000
Cross-Section Chi-square	306.8327	8	0.0000

In accordance with the results of *Table 4*, the hypothesis H_0 based on the intercept equality is rejected and the width of the different sources in the estimation should be considered. As a result, a panel method can be used to estimate. To determine the type of estimation method for constant or random effects, the Hausman test has to be analyzed as it is presented in the following table.

Table 5. Results of Hausman test.

Effecting test	t – statistic	Freedom degree	prob
Cross-Section random	11.5127	3	0.0000

Based on the results of Hausman test in accordance with the *Table 5*, the H_0 hypothesis based on the compatibility of random effects estimator is rejected and estimation should be done with using a fixed effect method.

5.1 | The Estimation of a Long-Term Relationship

After proving the panel cointegration association between model variables, without worry about the problem of false regression, we could use it to assess the long-run coefficients of the model variables. As it was mentioned, the FMOLS and DOLS method was applied to assess long-term association between the model variables. The results of these two estimates are shown for developing and developed countries in *Table 6* and *Table 7*.

Table 6. FMOLS-DOLS estimations results.

Dependent Variable: Logarithm of GDP								
Method of estimation: FMOLS					Method of estimation: DOLS			
Variable	Coeff.	Std	t-stat	Prob.	Coeff.	Std	t-stat.	Prob.
ln(ESI)	1.06	0.1044	3.7236	0.0003	0.78	0.0512	3.7231	0.0000
ln(FDI)	1.86	0.0695	2.5086	0.0000	1.08	0.1035	3.0022	0.0001
ln(TO)	0.98	0.2253	2.3598	0.0034	-0.16	0.1641	1.7182	0.0000
ln(L)	0.89	0.1611	1.6512	0.0000	0.19	0.1250	2.6235	0.0001
Intercept	1.81	2.1607	-1.5834	0.0006	-1.12	1.9323	-1.5640	0.0003
R-Squared	0.71				0.68			
Adjusted r-squared	0.69				0.61			
DW-statistic	1.86				1.93			

As it is observed in *Table 6*, based on validation criteria such as Durbin–Watson statistic, R^2 and R^2 adjusted statistics, the accuracy of results obtained from the estimation of both methods for analysis is confirmed. As it can be seen in the table, the results of estimating long-run relationship through DOLS and FMOLS estimators are almost similar to each other. Based on the results, the estimated coefficients for long-term relationships are statistically significant for all the variables (environmental sustainability index, FDI, trade openness and labor force). The FDI variable has the most impact on the economic growth variable. However, variable of environmental qualities index has a significantly positive impact on economic growth and after the variable of FDI; it has the most impact on economic growth. This means that these two variables are very important in economic growth. The impact of labor force and trade openness on economic growth would be positive in long–term and it is statistically significant at a high level.

5.2 | The Estimation of Short-Run Coefficients and Panel Causality Test

After estimating the long-term association between the model variables in two groups of developing and developed countries, short term association between the model variables and causality determination between individual variables are investigated. *Table 7* shows the long term and short-term tests of causality between the model variables. The optimal interruption rate in these models is selected based on Schwartz-Bayesian criterion.

Table 7. Causality test panel and short-term association between variables.

Independent Variables	Cause & effect resources (Independent variables)					
	Short-run					Long-run
	ΔY	ΔESI	ΔFDI	ΔTO	ΔL	ECT
ΔY	-	0.19**	0.29**	-0.08***	0.11*	-0.2155**
ΔESI	-0.29**	-	-0.13*	-0.08	0.02	-0.1124**
ΔFDI	0.31**	0.18	-	-0.28**	0.15	-0.5821
ΔTO	0.12	0.21	-0.18	-	0.07	-0.0812
ΔL	0.23**	0.09	0.27***	0.21	-	-0.0548**

*The value of coefficient β in the collection of *Eq. (7)* that is estimated based on the sum of coefficients with the lag of variables and indicates short-run causality related to each variable is presented in this table. *ECT* is error correction term, which represents the existence or absence of a long-term relationship. The numbers that are presented in the last column of this table show the coefficient λ in the collection of *Eq. (7)*. *, ** and *** indicate statistically significant at 1%, 5% & 10% level, respectively.

As it can be seen in the above table, based on the estimated coefficients in the model, the impact of environmental quality, FDI and labor on economic growth in short run are positive and is statistically significant at confidence level above 95%. However, trade openness in the short term has a significantly negative effect on economic growth. Therefore, considering total sum of coefficients with model lag, the effect of FDI on economic growth is 0.29. The effect is more than other factors such as environmental quality (0.19), trade openness (0.08) and labor (0.11). This result indicates the significance of FDI in economic growth. With regarding equation coefficients *Eq. (7a)*, it can be said that FDI

variable is considered as an effective variable on economic growth. The error correction term of this model equals to -0.21 and has a significant reliable level, which exhibits acceleration of modification to long term balance. This coefficient indicates that FDI and other variables investigated can overcome the 21% of the imbalances in the system in order to achieve a long-run equilibrium in each period. In the equation of environmental quality index, economic growth, FDI and trade openness in short term have a significantly negative impact on the quality of environment whereas the influence of labor force changes on the quality of environment would be positive, but it is not statistically significant. The negative influence of FDI on the quality of environment represents that multinational corporations increase production on the behalf of the expense of environmental pollution due to the existence of easy environmental regulations in developing countries. moreover, the coefficient of error correction term of the model is statistically significant at a high-level of reliability and in each period, the 11% of the deviations in the system are removed to achieve a long-term equilibrium. In the model of FDI changes, economic growth and trade openness, which have positive and negative effects on the increase of FDI respectively in the short term, are statistically significant. The impact of environmental quality and labor force on the increase of FDI would be positive, but none of the coefficients would be statistically significant. With regarding the insignificant coefficient of error correction in this model, modification to long-term equilibrium is not confirmed by FDI.

In the trade openness model, the role of economic growth, environmental quality, FDI and labor on trade openness changes are positive, positive, negative, and positive respectively and these coefficients are not statistically significant. Due to the insignificance of error correction coefficient in this model, it cannot be confirmed that there is a long-term association between the variables. In the model of labor force changes, the effect of economic growth and FDI on the labor force changes is positive in short-term and it is statistically significant whereas other obtained coefficients are not statistically significant. With considering the significance of the coefficient of error correction in this model, the long-term relationship between these variables can be verified statistically.

6 | Conclusion

Due to the more consumption of natural resources and energy, especially fossil fuels, and the achievement of higher economic growth, environmental hazards resulting from economic activities have become a controversial issue. In addition, the matter of FDI as one of the effective factors affecting the economic growth of countries can have positive and negative effects on the economy and the social status of each country and region. This research studies dynamic causal association between variables including economic growth, environmental sustainability index, FDI, labor and trade openness in developing countries for the period of 2000 to 2020. Therefore, in this paper, we have used Fully Modified Ordinary Least Square and Dynamic Ordinary Least Square for estimating long term association between variables of economic growth, environmental quality, FDI and trade openness and Pooled Mean Group has been used to estimate causality relationships between variables. developed

Results of long-term estimates of these variables represent that all of the variables (environmental sustainability index, FDI, trade openness and labor force) are significant. Therefore, the variable of FDI has the greatest impact on the economic growth. The variable of environmental quality indicator has significantly positive effect on economic growth; hence, after FDI, it has the most influence on economic growth. In other words, these two variables are very important in economic growth.

Environmental quality variables and FDI positively affected economic growth in short-term and are statistically significant. Nevertheless, trade openness variable is negative. With considering the sum of coefficients with model lag, the role of FDI in economic growth is more than other factors. This model error correction term is also significant at a high level of reliability and this indicates the accelerated modification towards a long-term balance. In the equation of environmental quality index, economic growth, FDI and trade openness in the short-term have a negative and significant role in the environmental quality whereas the influence of labor force changes on the quality of environment is positive, but it is not

statistically significant. In the environmental quality model, the impact of economic growth and FDI is negative. Coefficients of trade openness and labor force are positive, but these coefficients are not statistically significant. With regard to the significance of the error correction coefficients in this model, it can be confirmed a long-term association between the variables. Generally, as it can be seen from the short-term and long-term relationships, the association between quality of environment and economic growth is a two-way causality linkage in the short-term and long-term.

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Conflicts of Interest

The author has seen and agree with the contents of the manuscript and there is no financial interest to report. He certifies that the submission is original work and is not under review at any other publication.

Appendix A.

Table A1. The list of developed and developing countries.

Developing countries			
Iran	Turkey	Bulgaria	Indonesia
Iraq	Albania	Chile	Jamaica
Afghanistan	Algeria	China	Tajikistan
Angola	Azerbaijan	Ghana	Venezuela
Tunisia	Brazil	India	

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